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ABSTRACT

Designed to examine the academic computing programs of six liberal arts colleges that received funding from the Exxon Education Foundation for introducing or expanding academic computing between 1981 and 1983, this report first describes each college's program proposals. It then examines the progress of the colleges to date on their projects and their perceptions of success. In addition to these originally specified objectives, the report discusses common resources the colleges needed to support academic computing. The computer initiatives of the six institutions fall into three categories: (1) software development for particular courses at Smith College and Swarthmore College; (2) faculty development projects at Colby College and Hamline University; and (3) broad-based projects for enhancing computing resources and applications at Marymount College and Wells College. Four resources that played a central role in the success of the projects are discussed: money, time, knowledge, and a supportive environment. Finally, several conceptual frameworks are described that help to explain the evolution of academic computing at the colleges. The conclusion briefly presents some practical implications for colleges as they plan and/or expand their computing efforts and identifies several possible theoretical approaches to the study of academic computing initiatives. Descriptive case studies of the academic computing programs at the six individual institutions are appended. (JB)

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Final Report to the Exxon Education Foundation:

ACADEMIC COMPUTING PROJECTS AT SIX LIBERAL ARTS COLLEGES

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Executive Summary

This project studied six colleges that received funding from the Exxon Education Foundation for introducing or expanding academic computing between 1981 and 1983. As specified in the proposal, the report first describes the colleges' proposals. It then examines the colleges' progress to date on the projects and their perceptions of success. In addition to these originally specified objectives, the report discusses common resources the colleges needed to support academic computing. It also applies several conceptual frameworks to academic computing to suggest theoretical approaches for future research in this area.

The computer initiatives of the six institutions fall into three categories:

- software development for particular courses at Smith College and Swarthmore College,
- faculty development projects at Colby College and Hamline University, and
- broad-based projects for enhancing computing resources and applications at Marymount College and Wells College.

All of the colleges have met or are meeting their original objectives. While progress has not always been as fast as the colleges might desire, each of the projects is successful to date. These perceptions seem valid although there is little hard data to support them. As a result of the projects, more students and faculty members use computing and understand how the computer can become an integral part of their work.

From the common experiences of these six diverse programs, it is possible to distill four categories of resources which played a central role in the projects' success:

- Money. All of the projects required funding to support faculty members and hardware and software purchases.
- Time. Faculty members are already overburdened. A lack of time is a primary obstacle to success. Computing initiatives require means of providing participants with sufficient time to learn about computing and integrate it into their courses. The grants from the Exxon Education Foundation provided time, both directly and indirectly.
- Knowledge. Institutions require understanding of computing to integrate it into their educational programs. Each campus had one or more individuals who were knowledgeable about computing and willing to share their knowledge with others.
- A Supportive Environment. If institutional policy and characteristics do not support computing, the other resources are not sufficient to ensure success of computing initiatives. External funding can facilitate development of a supportive environment, but it is dependent on many other factors as well.

Finally this report describes several conceptual frameworks that help explain the evolution of academic computing at the colleges. An organizational perspective, for example, explains the process of implementing computer initiatives. A stage theory approach, which describes computing in evolutionary terms, suggests how computer use may change as campuses continue to explore computing. It also suggests questions for further research such as how computing affects the teaching-learning environment, the curriculum, and student-teacher interactions.

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Introduction

Computing has taken on a crucial importance to higher education. Colleges and universities spend millions of dollars each year to introduce and support computing for instruction, research, and administration. Yet despite the importance of computing, there is still much to learn about the key elements of implementing successful computer-oriented programs and particularly about using computing outside of the traditional spheres of science, engineering, and research. Robert Gillespie (1981) calls higher education's experience with computing an "accidental revolution." He cites the lack of comprehensive planning for the use of computing, secure funding sources, and knowledgeable faculty members to teach in an increasingly computerized environment as major elements of the accidental revolution. The problem is compounded because the available information on academic computing is largely descriptive. While it may be of interest to those who want to learn what others are doing, it fails to analyze institutional experiences with computing in a comprehensive manner.

This report has several objectives. As described in the project proposal, it first examines proposals the Exxon Education Foundation funded between 1981 and 1983 in the area of computing and higher education. This serves as the basis for the second step, an analysis of the perceptions and experiences on the campuses to determine if the colleges accomplished their original goals. Third the analysis describes the perceived success of the projects. In addition to these objectives from the project's proposal, the report also distills common elements or key resources from the colleges' experiences to examine what factors appeared to influence success. Finally the analysis suggests several conceptual approaches which might help colleges

understand the process of computerization and provide a framework for further investigations of academic computing. Thus this report includes but expands upon the objectives of the project proposal.

Method

The Exxon Education Foundation provided seven proposals funded between 1981 and 1983. While each proposal described several elements of the grant project, they can be differentiated according to the primary focus of the grant. Projects at Smith College and Swarthmore College were limited to software development for particular courses. As described below, those at Colby College, the College of Charleston, Hamline University, Marymount College, and Wells College were broader in scope. Because the College of Charleston's grant was quite recent and the institution had not progressed very far in the implementation process, it was not included in further study.

Site visits between October 1983 and February 1984 were the primary means of data collection at five of the six colleges. The visits typically lasted two days and included interviews with project directors, other faculty members involved with the project, administrators, and students. Documents related to the projects were another data source. These included proposals, evaluations, and planning papers. Telephone conversations and document analysis provided data for the sixth institution, Smith College. The narrow focus of the Smith project was the primary reason for this decision.

In total the principal investigator conducted 43 interviews at the six colleges. The introduction to each interview stressed that this project was not an evaluation for the Exxon Education Foundation. Respondents were told the primary purpose of the inquiry was to learn what worked in their project,

what did not work, and why. The interviews were unstructured, although each respondent answered similar questions. The major thrust of the questions centered on the individual's involvement with the Exxon project on the campus. Project directors answered questions about the origin of the grant proposal, their expectations of the project, their evaluation to date, and what they wanted to do with computing once the Exxon grant concluded. All respondents discussed their personal use of computing in the classroom and for other activities, what factors they thought aided implementation of the project, and what might have hindered progress. Faculty members discussed what the grant enabled them to do and if they would have pursued the same activities without the grant. Finally, respondents described institutional support for computing. Through their open-ended responses to these questions, respondents frequently volunteered additional information about the campus' use of computing and the reaction of the campus to the project.

Following each campus visit a case report was sent to the appropriate project director for his or her comments. Several of the project directors shared the drafts with others on their campus. While there were occasional differences in opinion about the cases, no major revisions were needed. The cases are appended to this report.

Through a cross-sectional analysis of the cases, this report identifies the key elements of the grant projects on each campus. As is evident in the following discussion, there are common themes and problems on each campus despite the diversity of the projects. This report will be of interest to the campus project directors who undoubtedly will want to compare their experiences to those of their colleagues at the other five colleges. It will be of interest to foundations which must identify proposals worth funding. Finally, it will be of interest to colleges and universities which must design and implement their own computer-oriented programs.

The Exxon Projects for Academic Computing

The Colleges' Proposed Projects

This section outlines the projects as presented in the colleges' proposals to the Exxon Education Foundation. It describes how the colleges planned to use the funds Exxon supplied and what they expected to accomplish. This is the first objective of this project. In all but one case, Hamline University, faculty members initiated the proposals. Faculty members with experience in computing took the initiative on the campus for further developing computer resources. While faculty members wrote the proposals, administrators and others on the campus with interests in computing supported and encouraged them. At Hamline, the proposal was part of the institution's computer literacy efforts and was largely written by the Dean of Liberal Arts. Figure One summarizes each project's primary goals. Appendix A contains complete case studies for the reader who wants to examine the individual programs in greater detail.

The projects at Smith College and Swarthmore College are more limited in scope from the other four. These two proposed developing software for use in specific courses; introductory geology at Smith and calculus at Swarthmore. The programs were to enhance lectures and class participation, and facilitate learning through making examples and theories more concrete. In addition to aiding students at their respective institutions, the project directors foresaw making their software available to faculty members at other institutions. The project at Smith also included compiling a catalog of software for geology courses available from other sources.

The projects at the other institutions had broader goals. The Colby College project focused on faculty development. Colby proposed several two-

FIGURE ONE
Project Goals

	Colby College	Hamline University	Marymount College	Smith College	Swarthmore College	Wells College
Faculty Development Seminars	X	X	X			X
Individual Faculty Projects	X	X				X
Faculty Retraining			X			
Developing New Courses			X			
Hardware Purchase		X		X		X
Software Purchase		X		X		X
Software Development				X	X	
Publications	X			X		

week seminars for 40 faculty members from all disciplines. Each seminar focused on topics of interest to particular groups of faculty members. Participants received a stipend for taking part in the program. The aim of the project was to spread computing throughout the curriculum and encourage computer use in the "normal context" of many courses. Colby hoped, as did the other colleges, that its program would serve as a model for colleges facing a similar problem of spreading computing throughout the liberal arts curriculum.

Hamline was one of the first universities in the country to require computer literacy of its graduating students. When Hamline's faculty passed this

requirement many of those voting were not yet computer literate. The university designed its Exxon project to help sixteen faculty members pursue individually tailored projects on applying computing in liberal arts courses. In addition to the individual efforts, Hamline planned a series of four one-day workshops to introduce other faculty members to its computer resources and the outcomes of the individual projects. Finally, Hamline proposed publishing a manual which would describe its computer literacy efforts and approaches other institutions take towards computing.

Marymount College proposed a more comprehensive program for academic computing. It included introducing a new minor in computer science, developing new courses, integrating computing into existing courses, and retraining faculty members. The project was part of a college-wide effort to improve the ability of students to use computers. The college has a basic computer literacy requirement but expects a large proportion of its students to move beyond an introductory level and about ten percent to become quite proficient in programming languages.

Wells College also proposed a comprehensive program in computing. Its first objectives, however, were to identify and investigate the appropriate role of computing at a small liberal arts campus. Wells also used some of the Exxon funds to purchase additional microcomputers, supporting equipment, and software. After these initial efforts, Wells planned a series of seminars about the college's computer resources for faculty and administrators. Wells expected that once faculty members became comfortable with computing, students would too. Wells projected that the grant program would eventually reach 700 students, faculty members, and administrators on the campus.

Thus the proposals share the common theme of expanding computing in innovative ways at the respective institutions. All of the projects are not yet

completed, but it is informative to examine the colleges' experiences and perceptions to date.

Project Outcomes

The second objective of this project was to determine if the colleges have met their goals. The colleges are meeting the objectives specified in their grant proposals. Most have not yet finished their efforts, but all feel they are making good progress. The campuses with broad programs have better developed computing programs because of the grant activity. Faculty development programs have reached their intended audiences. The general level of knowledge of computing has improved and there is an air of excitement as these colleges begin to visualize the possible uses of computing. More faculty members now use computing and a subset of this group applies their new knowledge in the classroom. At Smith and Swarthmore, software for specific courses has been developed or is in the process of being developed. Dissemination efforts, however, have not yet begun at most of the campuses.

The proposal for this project hypothesized that grant activities at the colleges might change between proposal and implementation stages because of technological advances. Although computing technology has changed since 1981, none of the colleges modified its program because of new technology. The college's hardware purchases, for example, reflect their proposals closely. Respondents stated that they consistently feel they are behind the latest technical changes. This may be due to constraints felt in implementing the grants. A more likely explanation is that the colleges are fairly risk aversive in expanding their computer facilities; they tend to acquire well established technology. The graphics software project at Swarthmore is one exception to this trend. In that case the project director felt comfortable

evaluating new hardware and plans on moving from it to more standard equipment when he makes his software available to others. The colleges also face the common problem of simply keeping up with technical advances which are available. Often they are not aware of the latest technology. This may change, however, as computer companies begin to view the higher education market with greater interest.

In addition to the expected and planned outcomes from the Exxon projects, there are unexpected outcomes. Several of the colleges have found that their project reached a larger audience than orginally expected. At Wells College, for example, more administrators and staff members have participated in the workshops than originally planned. The catalog of geology software that Burger compiled at Smith College is much more popular than he expected.

Another unexpected outcome of the Exxon projects is that they have attracted additional external resources for computing projects at many of the campuses. The Exxon funds have been "seed money" for additional grants, equipment discounts, and equipment donations. The project directors at Marymount and Wells stated that the Exxon project demonstrated to other funding sources that the college was serious in its efforts to upgrade computing and integrate it into the curriculum. The projects also showed that the colleges were capable of undertaking such activities successfully. Campuses which have not yet sought additional funds feel that the Exxon projects will help them obtain more funding in the future.

Finally, some of the campuses have found that the computing project has been an unexpected means of increasing communication among faculty members. When faculty share a common interest in computing or, more specifically, use similar programs and software packages, they talk with and help

each other. This is particularly interesting when such communication crosses traditional disciplinary boundaries.

Perceived Success

Marymount is the only college that has completed the evaluation phase of the project as described in the grant proposal. But the project directors and most participants agree that the projects are successful. Marymount has a new computer science major. Over forty faculty members at Colby now have computer terminals in their offices. Eighty percent of Wells' faculty members have participated in a computing seminar. Geology students at Smith use new software in introductory classes. Project directors and participants credit their Exxon project with providing the resources and much of the impetus for successfully advancing computer use. While there is always room for improvement in project activities such as faculty seminars, the campuses are pleased with their efforts.

Despite this generally accepted evaluation, there is little data to support the perception of success. The colleges with faculty development and broad-based programs, for example, do not have accurate data on the number of students that use computing or the number of classes with computer assignments. There are data on the number of faculty who have participated in seminars, but there is little information about how that participation translates into actual classroom experience, changes in courses, or improved learning. Most of the data are anecdotal in nature; stories about which professor is now using which type of software in his or her classes. Collecting data is time consuming and of less importance than teaching faculty members and students about computing and encouraging them to use it. Neither software development project has yet completed a formal evaluation either.

There is some debate and disagreement on the campuses about what constitutes innovative computer applications. At several colleges faculty members are trying to determine what level of computer use is appropriate for their classes and students. Some faculty members would only include actual hands-on computing. But one project at Hamline, for example, led to a discussion of the influence of computing in a course on medical ethics. Such social implications of computing are often included in definitions of computer literacy. Some faculty members do not think that Computer Aided Instruction (CAI) is appropriate for college students because of its simple rote learning structure. Others disagree and feel it is useful for teaching factual information. This debate is yet to be resolved. Academic computing is still evolving on the campus, and the debate over appropriate use is part of this evolution.

The debate about how to best use computing is part of the on-going success of these projects. While all of the campuses have enhanced computing, none appears content to remain stationary in the future. There are always demands for increased capacity, more convienient facilities, and specialized hardware and software. Beyond this, however, members of the college communities are engaged in debates about computing's place in a liberal education, the development of new programs and majors, and how computing will affect their institution. It is also clear that the colleges will continue to advance their use of academic computing. The colleges have had positive experiences with their grant projects. Others who want to follow in their footsteps will certainly benefit from the projects. The broad-based programs can be replicated on other campuses which will use them as models. But perhaps more important than describing these cases is identifying the

elements of the projects that led to success or slowed progress. The following section distills the important resources for others to consider in their own computer-oriented projects.

Key Resources for Academic Computing

Project directors and participants in the Exxon grant projects shared common experiences and perceptions despite the diversity of the programs and campuses. It is possible to distill fundamental elements from these six cases. Successful innovation with academic computing appears to depend upon four broad categories of resources: money, time, knowledge, and a supportive environment. This section of the report describes these key resources. They are resources any campus must consider in planning and implementing a computer-oriented initiative. The first three, money, time, and knowledge, need little explanation. The fourth, a supportive environment, deserves detailed attention.

Money

The Exxon grants obviously provided additional funds with which the colleges could expand their computer initiatives. The grants provided funds to purchase equipment, pay faculty to participate in special workshops, pay student assistants, and so forth. As one project director stated, the grant provided "slack resources" with which the institution could experiment. Many of the colleges use external funds like their Exxon grant to initiate new programs and commit college resources to support on-going programs.

Some of the most important monetary resources were those for faculty support. In addition to the project directors, the grants funded faculty members' participation in summer activities and special seminars. In some cases these funds were clearly a motivating force for involving the faculty members. This was true, for example, in large summer projects such as those at Smith and Swarthmore and for summer faculty seminars at Colby and

Marymount. The payment legitimized faculty participation in the grant activities. Without the funding some faculty members would have been forced to find other activities with which to supplement their income. The funding provided the necessary incentive to ensure participation. Other faculty members, however, would have participated in the grant activities even without payment. They were interested in computing and wanted to learn more about it. The value of stipends for faculty members appears to depend on the type of activity they are pursuing. Faculty in group seminars seem less motivated by stipends than those pursuing individual projects. Faculty participating during the summer months appear more likely motivated by a stipend.

Time

As important as dollar resources, the grants provided extra time for faculty members. Like their colleagues on most campuses, the faculty members at these six institutions have a number of conflicting demands on their time. They are overtaxed and stretched to the limits. The lack of sufficient time to pursue their interests in computing was mentioned by virtually every faculty member interviewed. Some of the Exxon grants provided release time for the project directors. This was important at Wells, for example, because it gave the director time to consider how the college could best use computing and what approach was appropriate for a small women's college such as Wells. Release time also provided enough slack to allow faculty members to develop faculty seminars, to plan campus computing activities, and to pursue individual projects.

The Exxon grants also provided time indirectly. Paying faculty often helped legitimize their work on computer-related projects. They felt obligated

to pursue their computing interests when they were being paid to do so. As mentioned above, summer funding for some faculty members meant they could take the time to learn more about computing and revise their classes. Finding sufficient time to learn about computing and then revise old courses to include computing or design new courses is crucial to the success of the campus projects. The grants were one source of that time.

Knowledge

While the grants provided the campus with "slack resources" which enabled them to implement new projects, there are other resources that the grants cannot provide directly. One of these is knowledge. Each project depended on the specialized knowledge of a few individuals, most frequently the project director. They became the "experts" to whom others would turn when they had questions and problems. As more faculty members and students learn about computing, they too become known as campus experts. At Wells, for example, there are faculty experts for several software packages and students experts who have computerized several administrative functions. Most individuals on the campuses are quite willing to share their knowledge with others in this fashion. Unfortunately, however, this often aggravates the problem of insufficient time for the campus experts. Yet, most knowledgeable individuals on the campuses help others with questions and problems. Without the willing sharing of knowledge, the colleges would not have made the progress they have.

A Supportive Environment

The Exxon grants provided resources such as money and time. They indirectly supported and developed knowledgeable individuals. They also

enhanced an environment on the campuses which increased the likelihood of successful implementation of computing initiatives. A supportive environment is the most complex of the four resources. It includes institutional policy and practice in areas such as managing computer resources and computer literacy. But it also includes intangible characteristics of the institution. While successful projects are less likely without money, time, and knowledge, an unsupportive environment can decrease the chances of success even if the other resources are present. The elements of a supportive environment discussed below include facilities, resource allocation, support personnel, computer literacy policy, and institutional characteristics.

Facilities. Computer initiatives obviously require computer facilities and managing these resources consumes time and energy on the campuses. And in an environment of rapid technical change, managing computers is even more difficult. The old facilities debate focused on centralized versus decentralized and academic versus administrative computing. These issues are still important, but most campuses are moving towards decentralization with the proliferation of microcomputers. The actual policies and procedures a campus follows are not as important as the results of its approach to computer management. Faculty and student users are concerned, for example, with the availability of the hardware and software they need.

Many campuses also face the questions of which microcomputer(s) they should purchase, how to coordinate the purchases of autonomous faculty members and students, and how to link personal computers to central facilities. The specific answers to these questions vary widely from campus to campus. More important are the issues these questions address: the availability of computer resources, meeting users' needs for both hardware and software, educating faculty and students on what is available and how to use

it, and so forth. If facilities are not easily accessible, convenient, stable, and capable of meeting the users' needs, they limit progress.

Another major problem is identifying appropriate software and application packages. It is difficult to know what software other colleges use, how to obtain it, and if its quality is adequate. Available catalogs often do not evaluate software, so the faculty member must decide to purchase it before knowing if it is appropriate or effective. Overcoming obstacles such as these slows progress even further because of the demands they make on faculty members' time.

The additional resources from the Exxon grants did not solve the problems of managing computer resources. Managing facilities still consumes a great deal of time and energy. In part the changing nature of computer technology causes this problem. Those campuses with older, central computer facilities find that just as they think problems are solved, faculty members and students demand microcomputers. The proliferation of computing may aggravate management problems as campuses deal with issues such as networking, communication, maintenance, purchasing, and security. Many of the colleges also find that as more faculty and students learn what a computer can do for them, they demand more of the resource, and campus facilities cannot keep up with demand. Yet continued success requires that they do so.

Resource Allocation. The allocation of computer resources is another aspect of academic computing's environment. When there are sufficient resources to satisfy all users, allocation is not a problem. But when, as is true on most campuses, there are insufficient resources, the college needs a clearly defined allocation policy to distribute computer resources among competing users. A stable and understandable allocation policy is the users

guarantee of access and availability at reasonable cost. If the computer resources are not convenient and available, the likelihood of successfully implementing a computer initiative declines. The most common approach to allocation on the six campuses was free access or first-come, first-served. This is fine when there are adequate resources. But as demands increase, first-come, first-served can mean uncertain and inconvenient access to computing. This can be a major block to successful computing initiatives. Thus a college must plan and implement successful allocation policies to enhance the success of computer initiatives such as the Exxon projects.

Personnel. Computing obviously depends on computer equipment, both hardware and software. But without support personnel, facilities are worthless for many users. On some campuses computer center personnel are technically oriented. They focus on equipment and software, use jargon, and seem remote and inaccessable to many users. Other support staff are oriented towards the user. They translate jargon into the user's language, they focus on user needs rather than technical problems, and are readily available to users who need assistance. Which type of personnel are available on the campus depends in part on institutional policy. At the six campuses user-oriented support personnel were available, but they were not always part of the computer center staff. At campuses with more technically oriented computer centers, other individuals on the campus sometimes became experts who willingly helped others.

Computer Literacy. A college's approach to "computer literacy" influences other areas of academic computing. Currently many campuses are still engaged in debates over the meaning of "computer literacy" and whether or not it should be a requirement. Some require computer literacy, others encourage it, and some have not formulated a policy. Faculty members on

campuses with a requirement feel more urgency to promote and integrate computing in their classes. The campus that requires student computer literacy before faculty members are comfortable with computing will have one environment. A college will have a different environment if it begins with faculty computer literacy in the hope that as faculty members become more comfortable with computing they will use it in their classes. Yet all of the colleges that received Exxon grants recognize the importance of computing even if they do not have a stated requirement for computer skills and understanding. Institutional computer literacy policy can be a resource the college draws upon in its computing initiatives.

The campuses followed several strategies to introduce faculty to computing. They used group classes, individually tailored efforts, or both methods. The classes focused on programming and packages such as word processing, spreadsheets, and data base management. Some colleges now feel that programming is less important if there are available software packages which are appropriate for faculty and course use. Hands-on training in a computer lab was part of each program. The group activities appear to be successful for introductory training of new computer users. It is more efficient, but it also enables the faculty participants to see their colleagues in a learning situation. Many individuals commented on this. Class participants could draw upon one another both during and after the seminars.

Getting faculty members over the initial hesitation and fear of computing is often seen as the biggest hurdle of computer literacy. But the need for support and further training may be more important in the long run if faculty members are to use computing productively in their classes. Some faculty members may share common interests in particular software packages or applications and benefit from learning together. As faculty members' computing

skills advance, individually tailored projects may be more appropriate. As colleges progress with their computing efforts, many are finding that the need for support continues to increase as faculty members use computing in many aspects of their work.

Institutional Characteristics. While attention to facilities, resource allocation, personnel, and computer literacy does not assure success, inattention often leads to failure. In addition to well managed computer resources the progress of the six colleges depended on a number of institutional characteristics. These relate to the college itself and the people who work there.

The basic nature of the education the colleges offer and their curricula affected their experiences with the Exxon projects. Those with an established major in computer science or an engineering department had technical resources that were unavailable on other campuses. Institutions that have traditionally offered degrees and programs in more technical areas may also find less resistance to computing than those that offer only the traditional liberal arts. If the institution already values career-oriented or practical majors, it is likely that it will introduce computing programs of a similar nature. If, on the other hand, it stresses the traditional liberal arts, computing will more likely support other areas of study as a tool.

The orientation of the campus towards teaching and research also plays a role in the institution's response to computing. Faculty members at colleges with a greater emphasis on research may be more knowledgeable about computing if they use it in their research. They may not have translated that knowledge into classroom experiences for their students, but at least they are familiar with computing. Campuses with a primary emphasis on teaching may have faculty members who are less knowledgeable about computing. Each position has its advantages. The research-oriented faculty member may not

need to learn about computing, but may need extensive encouragement to take the time and effort involved in redesigning his or her courses to include computing. The teaching-oriented faculty member, on the other hand, probably needs less encouragement to apply computing in the classroom, but first needs to develop the necessary familiarity with computing to learn to use it appropriately.

Closely related to the research-teaching issue are institutional rewards for involvement with computing. Institutions which reward innovative and effective teaching during review for promotion and tenure, for example, may find faculty are more enthusiastically involved with computing than those which reward research and publications. Several faculty members I spoke with at Colby, Smith, and Swarthmore thought that they would spend less time on creative computer applications in the classroom and more time on research if they were not tenured. At other campuses untenured faculty felt that time spent on applying computing to their teaching was a good investment the institution would recognize. The institutional response may depend on who makes the promotion and tenure decisions and whether or not they are computer users. Institutions must realize that faculty reaction to computing depends in part on institutional reward structures.

Rewarding time spent on computing is only one form of institutional support for computer initiatives. Success also requires resources such as money, time, and space. Gifts and grants for computing resources require on-going institutional support. This includes a financial commitment for maintenance, supplies, and personnel to aid users. Computer initiatives will require faculty development efforts at least for the foreseeable future. Faculty members need time to learn how to use computing in ways that are appropriate to their discipline, courses, and research. They need the

facilities, including special software and hardware, that permit them to use the computer in a way they define as appropriate.

People on the campus are another part of the institutional environment. Each of the six colleges that received an Exxon grant had one or more individuals on the campus who were totally committed to the project, most often the project director. They approached computing with energy, enthusiasm, curiosity, and excitement. They willingly gave of their time, often to the detriment of their own work. They assisted others on the campus, they answered questions, prompted involvement in grant activities, and worked to ensure the success of the grant project. Without these individuals, or someone else with similar characteristics, the institutions would likely not have received the grant or made progress in their computer initiatives.

Some of these same characteristics are also true of faculty members who became actively involved in the computing projects. Once involved in the project they tend to share the enthusiasm and interest of the project directors. It is difficult to predict, however, which faculty members will become actively involved. It seems to be somewhat related to age, but it may be more a function of whether or not the faculty member used a computer in his or her own graduate education. Interest and involvement also relates to the willingness to experience and accept change. Like the project directors, the involved faculty come from many departments including those that have not traditionally used computing. Project directors often have a gut level sense of which faculty members they can involve in computing projects, but they are unable to articulate the particular qualities of other faculty members that make them good candidates for participation. Finding and involving these individuals, however, is crucial to success.

Communication among faculty members also appears to influence the implementation of computer initiatives. Particularly at smaller colleges, faculty may find it easier to share their work with colleagues who have a common interest in computing. They may also be more willing to take the time to do so if they know their colleagues well. Faculty members who do not use computing or who are less advanced in their applications are likely to have a better sense of what others are doing with computing on a small campus. This often translates into questions and interest that prods them into becoming more actively involved. Once faculty are involved, some campuses have found that a common interest in computing brings faculty members from different departments in closer contact. They share ideas, techniques, software, and problems. They learn what their colleagues are doing. This atmosphere encourages computing initiatives and enhances success.

The characteristics of administrators may also influence the success of computer initiatives. Some administrators actively support and promote computing efforts, some encourage faculty to work in this area but take a less active stance, some realize the benefits of computing but let faculty take the initiative, and some may try to discourage progress if they feel it is not as important as other institutional needs or is incompatible with the institution. While faculty with sufficient interest and ingenuity can usually work around this last category of administrator, the type and intensity of administrators' support can be an active and positive influence on computing.

Facilities, resource allocation, personnel, computer literacy, and institutional characteristics all interact in a complex manner. The continuing need for support for faculty involvement with computing illustrates this. As faculty become more involved in computer literacy efforts, they require additional computer resources, personnel to support their work, and institutional

support in the form of hardware and software packages. Campuses which want to replicate any of the six projects described in this report or which plan their own projects must consider each of the four types of resources. While progress is possible without each of the four, they work together to increase the likelihood of success.

Conceptual Approaches to Academic Computing

There are three basic approaches to academic computing in the literature: surveys of computer use and management, position statements on the value of computing, and case descriptions. Conceptual approaches to understanding the use and management of academic computing are unfortunately missing. There are several likely explanations. Each approach in the literature is useful. The surveys provide valuable statistics and are helpful at a level of broad policy formulation. The position statements may convince a few skeptics of the inherent worth of integrating computing into the postsecondary curriculum. And colleges which are planning computer initiatives are interested in reading case descriptions to learn what others have done. Furthermore, colleges in the midst of implementing a computer initiative usually have little time to study what they are doing from a theoretical perspective. As computing continues to be of increasing importance to colleges and universities, however, it is useful and valuable to apply a conceptual framework to the phenomena to explain the process, predict future directions, and help colleges and universities reach new goals. This section of the report briefly introduces several conceptual approaches to academic computing. Each has implications for practical applications and future research.

Organizational theory provides a useful starting point. At a broad level organizational theory explains some aspects of the computer revolution. The descriptions of colleges and universities as political organizations certainly fit the experiences of many institutions as they implement computer initiatives and programs. Fierce political battles can occur over these issues. Campuses with committees to oversee computing may find their actions replicate the theoretical description of garbage can decision making. Participation

is fluid, every actor has his or her own solution (usually a favorite piece of hardware or software), and the same issues seem to arise repeatedly. Thus the investigation of academic computing can illustrate and validate several approaches to organizational decision making. Academic computing is no different than other problems colleges and universities have faced in the past despite the jargon and high tech image.

Technological innovation is another useful conceptual perspective. There is a vast literature on technological innovation. One branch of the literature focuses on organizational characteristics that affect innovative behavior. Large organizations, for example, tend to be more innovative than small organizations. Innovation is more likely in organizations which have slack resources, greater levels of specialization, individuals who fulfill certain types of role behaviors such as gatekeepers and product champions, and environments which demand change. These same characteristics apply to innovative academic computing programs on college and university campuses. They also relate to the four categories of resources discussed in the previous section. Innovative organizations are those with money, time, knowledge, and a supportive environment.

Universities such as Carnegie-Mellon, Brown, and the Massachusetts Institute of Technology have all received sizeable amounts of external funding for their innovative applications of academic computing. This same phenomenon is visible at the colleges with the Exxon grants. Although most reported that they would be working in the area of academic computing even without the grant, the slack resources the grants provided certainly accounted for their more rapid progress. Their small size and lack of a large number of specialists also seemed to hinder their initial progress with computing. They were not the leaders of innovative computing practices. And

they all felt external pressures for providing students with adequate computer facilities, courses, and opportunities to use computer resources in their classes.

Another part of the innovation literature studies the diffusion of innovation within social systems. It identifies the characteristics of those individuals who are relatively late and early in the innovation process. This too is a relevant approach to studying the diffusion of computer use on one campus. It may help explain why some faculty members are more interested than others in learning about computing.

A third promising approach is the theoretical perspective of organizational change. The Lewin-Schein model of organizational change (unfreezing, moving, and refreezing) certainly applies to academic computing. Faculty members, for example, usually will not become involved in computer initiatives until they understand the reasons or feel the pressure to do so from students, colleagues, or administrators. A faculty development seminar can constitute the moving phase of the change process. In the seminar the faculty member learns the fundamentals of computing and how to apply them. In the refreezing phase the faculty member makes permanent changes in his or her classes and thus incorporates the change produced by the seminars. Unfortunately the evidence gathered to date does not address the problems of refreezing. It is not clear how the computer initiatives influence the participants' classes, for example. Providing stipends or other institutional rewards may involve faculty members in the computer initiative, but they do not guarantee continued success.

The perspective of organizational change leads to some other interesting observations. The presence of someone to facilitate the change process increases the likelihood of successful implementation. Individuals who

introduce users to the computer, teach more advanced applications when appropriate, answer technical questions, and translate jargon into language the user more easily understands are present on the Exxon campuses with broad-based computer initiatives and faculty development programs. These individuals help users internalize computing or make it part of their academic work. They also help the organization institutionalize computing or make it an accepted part of the organization. These individuals help users and the organization progress through the change process and integrate computing into traditional areas and programs. They are part of a supportive environment for academic computing.

A final perspective which is useful in explaining academic computing is a stage theory approach. The evolution of computing is evident in both the management of computing and its applications. In early stages organizations focus on elementary data processing tasks and the technology itself. As computing evolves, the focus shifts to control of the resource. In later stages the primary interest is in using information effectively for a number of purposes. Over time attention shifts to what the technology can do for the user and how it can be used effectively in a wide variety of applications. As organizations pass through the stages it is likely that they require different amounts and types of resources to support their progress.

As the stage theories predict, there appears to be a slow shift away from technology, cost control, and programming as the primary interests. Faculty members from different disciplines are now discovering new applications and are far more interested in what the technology enables them to do. Programming is not as important to all users as it once was. And rather than confine computing to computer science and mathematics courses, colleges and universities are finding it useful in all disciplines. The stage theories

help explain computerization and may help institutions understand the process they are intimately involved with. The stages can also identify what to expect as the process continues.

Each of the perspectives discussed above contributes to a further understanding of academic computing on the college and university campus. They are also complementary in nature. Technological innovation requires an implementation process which the organizational change literature describes well. And as colleges and universities continue to implement innovative techniques, they evolve through the stages described above. Each conceptual approach explains a different facet of the process. They may be helpful to campus leaders who are trying to understand the evolution of computing on a particular campus.

The conceptual approaches can also serve as the foundation for further research in this area. The literature on technological innovation, for example, suggests the importance of the resources discussed above. The relative value and role of these resources should be examined across a broader base of institutions. The interaction of the resources and the stages of academic computing deserve further attention. Do different stages, for example, have different resource needs? And the resources may affect the implementation process. This too deserves careful study in a larger sample. An additional area of future research concerns the future development of academic computing. As it evolves, what are the future stages of computing on the campus? Will there be changes in the curriculum? Will possible changes occur in all types of institutions? Colleges and universities are caught up in the process of the computer revolution. Futher research can help them understand the process, where they are headed, and the implications of these changes.

Conclusion

There is diversity among the six Exxon projects, yet they illustrate common perceptions of the computer revolution on the American college campus. As some institutions plan initiatives and others expand their current computing efforts, several practical implications of these commonalities appear:

- Computing requires tremendous institutional support and encouragement. It obviously requires financial resources, and grants such as those from Exxon help meet the financial need.
- Faculty members need sufficient time to learn how to apply computing in their courses and time to revise existing courses and design new ones. Faculty members cannot make extensive changes and revisions on top of already overloaded schedules.
- Computing needs adequate and convenient hardware and software to meet the special needs of faculty and student users.
- Educating and involving those users requires training and continued personnel support. As the user base expands over the next few years, the need for personnel support will grow too. Users need support staff who can answer technical questions, translate jargon, identify potentially useful software packages, and suggest more advanced computer applications.
- Finally, the institution must support and reward those faculty members who are successful in their efforts to integrate computing into their courses. If such work does not enhance the likelihood of promotion and tenure, faculty members will not participate in computing initiatives.

The institution must encourage and support computing in many ways. Financial resources alone are insufficient.

Studying the six colleges with Exxon grants also identifies several possible theoretical approaches to the study of academic computing initiatives. Several branches of organizational theory are encouraging.

- Future research should continue to apply the theories of innovation to academic computing. Such work could identify organizational characteristics that might limit an institution's likelihood for successful implementation of a computer initiative.
- Future research should carefully examine computing initiatives from the perspective of organizational change. Such work could identify other factors that influence a college's ability to successfully navigate the phases of organizational change. These efforts should include formal testing of the importance of the four resource categories -- money, time, knowledge, and a supportive environment -- in the successful implementation of academic computing.
- Future research should examine academic computing in light of the stage theories of computer evolution. The stages appear to describe the process of computerization. If this is true, knowledge of the stages may assist an institution that is in the midst of the process. It might also identify the next stage of the evolutionary process and the resources required to reach it. Few institutions if any have advanced to the latter stages and it is not clear what the characteristics of future stages are.

The next stage the computer revolution may involve fundamental changes in the teaching-learning environment on the college campus. The attention

surrounding the computer revolution to date has not examined how computing is changing the interaction of faculty members and students, the ways in which students learn, how computing might change the curriculum, and what this means to colleges. Several universities such as Brown, Carnegie-Mellon, and Massachusetts Institute of Technology have initiated large projects in this area with substantial support from computer manufacturers. These issues must also be studied at smaller campuses which must proceed without such extensive external support.

APPENDIX A

COLBY COLLEGE

Colby College received an Exxon grant for a project designed to increase the use of computing throughout its liberal arts curriculum. The grant proposal called for a series of two-week summer seminars for faculty members in different disciplines--the natural sciences, social sciences, and humanities. The seminars were to include 40 faculty members over a two-year period. Additional funds were available for summer stipends and release time for faculty members to locate and adapt software for use in courses at Colby. Dissemination of the Colby model was a final objective of the proposal.

Colby is still in the midst of the Exxon grant. The college offered seminars to faculty in January, 1983 and additional seminars during the summer of 1983. Faculty members report positive experiences in the seminar programs. One seminar series, aimed at new computer users, focused on an introduction to computing at Colby and using word processing. Another seminar, for somewhat more sophisticated users, dealt with UNIX (the operating system on the college's VAX 11/780). Faculty members received $250 for each week they participated in the seminars. While some faculty state that they would have participated without the stipend, others say it was a large incentive. The monetary reward is clearly helpful in interesting some Colby faculty in learning more about computing in their discipline.

Colby faculty are integrating computing into their liberal arts classes. Common examples are data analysis assignments in social sciences, modeling in biology, and word processing in English and the humanities. To date it appears that faculty have primarily used computing to support traditional teaching methods. It is also apparent that there have not been any fundamental changes in the Colby curriculum. This is consistent with the college's

philosophy and has been its goal. There are cases where computing has facilitated new approaches such as the analysis of Supreme Court decisions and the voting behavior of the justices in a government course. In fact, while Colby's faculty endorsed a policy on "computer literacy," they did not define the term.

A number of factors appear to have enhanced the effectiveness of the Exxon grant in promoting the expanding use of computing on the campus. The seminars clearly have a number of faculty members thinking about computing and how they can use it in their courses. Some may disagree with the ways in which their colleagues use computer resources, but the interest is present.

The process the grant helped set in motion also interacts with other factors at the college. There is an environment conducive to the growth of computing at Colby. It is not clear whether the grant produced an increased commitment among the college's administration, but that commitment is present at the college. The best example of this is a new policy, approved by the Board of Trustees, to provide an in-office terminal for every faculty member who expresses a need for one. In addition, faculty members feel that the college will reward their interest in computing. Teaching is an important aspect of the faculty member's job and excellence in teaching appears to be important in tenure and promotion decisions. Faculty members think that their time and effort to integrate computing into their courses will be viewed favorably as part of their teaching duties in the evaluation process.

Thus faculty members and administrators are thinking about the issues of computing in the liberal arts curriculum. The Exxon grant is one part of that process. The development of computing has been enhanced by the administration's commitment. It is also benefiting from a Sloan grant the college recently received.

While Colby's experience is positive, there are a number of other factors that are slowing progress and inhibiting the integration of computing into the liberal arts curriculum. Some of these are more easily dealt with than others. Primary among the difficulties is a lack of human resources. Like personnel at many small colleges, Colby's faculty work extremely hard, dividing their time among teaching, research, and community service. Many simply do not have sufficient time to explore computing at length and produce new applications for their classes. The interest is present but the time is not. Using January and summer months is one way around this problem, but faculty have other commitments during the summer or must use it for research. During the academic year it is difficult to find blocks of time for large tasks. Only those who are highly motivated can be counted on to make progress during the school year.

The second deficit in human resources is in personnel to assist faculty members with their computing efforts. The college is looking for an individual to coordinate academic computing. The individual hired for this task last summer did not take the job. (He has, however, consulted with Colby and taught the seminars offered to date.) The presence of an individual on the campus to coordinate efforts and act as a central resource will be beneficial. While faculty can and do turn to staff members in the computer center, those staff have more than enough to keep them busy. Their intentions appear to be good, but once again there is not enough time to meet the needs of all users.

Another factor hindering the integration of computing into the liberal arts at Colby is the common problem of coordinating and managing computer resources. The college has expanded facilities significantly over the past several years. This in itself is a major accomplishment. But it takes time

and effort. Faculty members may not always receive the equipment they need (graphics terminals or a conveniently located printer). In addition, orchestrating major hardware acquisitions and their installation decreases time available for other tasks.

Colby has followed the centralized facility model in developing its computer resources. There are only a few microcomputers on the campus and they are primarily used for specialized tasks such as data collection. There is some question as to how effectively centralized facilities can meet individual needs. One example is the placement of printers for word processing. The computer center's proposed solution of a centralized printer may not meet the needs of those who would prefer a number of slower printers scattered across the campus. Another example is the current lack of support for microcomputers. The central staff questions their cost effectiveness (for example their lack of use at night) while faculty members complain that centralized facilities are not useful if they are unavailable because of high demand. This issue has not been resolved, but because the issues of computing are openly discussed and considered on the campus, it is likely that Colby will confront it in the near future.

It is too soon to evaluate the absolute success of the project at Colby, even if that were the object of this summary and success could be easily defined. Colby is exploring and growing as it becomes more familiar with computing and the liberal arts. Several observations are possible however. While some on the campus might disagree, there do not appear to have been any fundamental curricular changes in the Colby curriculum. Computing is supporting the liberal arts but not in a radical way. A good example is found in the English Department. (Interestingly the four English professors involved in the computing seminars are all part-time.) Word processing is

used in a few writing courses, but the style of instruction has not changed. Some faculty members use the computer simply as a fancy typewriter and editing tool. In these initial efforts the computer's full potential may not be used.

While there is a general perception on the campus that efforts to integrate computing are successful, there is little data to support these claims. For a variety of reasons, such as the peculiarities of operating systems and the independent habits of professors, there is little data on the number of students, courses, departments, or faculty members actively using computing in the classroom. Thus it is hard to quantify any increase in the use of computing. Yet most agree that computer use is climbing rapidly and steadily. Better data would permit comparisons as the process continues. But collecting such data may be less important than furthering the process of computer integration itself.

It is also important to note that there are "pockets" of computer use scattered among the departments and faculty members. It is a matter of individual interest and commitment as to where computing is increasing. Several faculty members who are the heavy computer users are known to the college community and others turn to them for guidance and assistance. They are the local experts. Yet the number of such individuals is quite small. Colby needs of a better means of sharing faculty knowledge and expertise. Rather than rely on traditional departments and disciplines as the vehicle for expanding faculty contact, it might be more beneficial to group faculty members by their primary use of computing. For example, there are groups of faculty members whose primary use of computing is word processing. They could share and learn from each other. Another group might focus on data analysis and a third on modeling. While content would vary, the techniques and approaches to computing would be similar. Faculty members are an important

resource in the integration of computing into the liberal arts, and finding a means of utilizing this resource is crucial.

The Exxon grant at Colby is having its intended effect. More faculty members are using computer resources in their courses. A major obstacle is the lack of time. But the Exxon funding has enhanced the process at Colby. It has prompted the college to undertake at a faster pace activities that probably would have occurred any way. It is the seed of many related activities that all promote an increased use of computing in the liberal arts.

HAMLINE UNIVERSITY

Hamline University was one of the first institutions in the country to establish a computer literacy requirement for graduation. When the faculty passed the requirement for students entering in the fall of 1982, however, Hamline had minimal computer facilities--a small PDP 11/23 and a remote batch connection to the Control Data Cybernet system. The college purchased a Digital VAX 11/750 in August of 1982 to support the computer literacy requirement. (There are terminal clusters in the science building, the library, and a classroom building.) Hamline also uses Control Data Corporation's PLATO system and is converting to micro-PLATO for several courses including its introductory computing classes. When Hamline purchased the VAX there were faculty in the sciences and math who used computing, but the majority of faculty members were unfamiliar with computer resources. Hamline asked the Exxon Education Foundation for funds with which to educate and involve faculty members in computer literacy and Exxon provided resources for this purpose. Hamline has completed the first of two years in the Exxon project.

The grant proposal outlined three major elements of the program at Hamline. First, and most important, are sixteen faculty development projects. The $1,500 stipends enable the faculty to pursue individually tailored projects during the summer months. The projects center on classroom applications in the faculty members' disciplines. Six of the sixteen faculty development projects were undertaken in the summer of 1983. The remaining ten will take place during the summer of 1984.

The second element of the program are four one-day faculty workshops. The first of these occurred in October, 1983. Some of the faculty who had received a 1983 summer stipend presented the results of their work at that

time. Agreeing to make a presentation at one of the workshops was a condition of accepting a summer stipend. Through the workshops the entire faculty has the opportunity to hear about the summer projects and their classroom applications. Suggestions from evaluations of the first workshop will be incorporated into the second workshop in April, 1984. These will include an opportunity for faculty to participate in a hands-on introductory session when students are not allowed in the terminal rooms.

The third element of the Exxon program at Hamline is the production of a computing resource manual. In addition to containing descriptions of the sixteen faculty projects, the manual will include more general information on issues and practices of computing in the liberal arts. The project director, Gary Anderson, will compile the manual. Each stipend recipient will give Anderson information on his or her project. Because of the publicity Hamline received about its computer literacy requirement and a notice about the manual, Anderson has received between 700 and 800 requests for the manual. He foresees finishing it in the summer of 1985 after the faculty development projects and campus workshops are complete.

The Exxon project also included small amounts of funding for special software and hardware purchases related to computer literacy. Thus a faculty member who did not have a stipend but was interested in exploring a particular software package might obtain funds to purchase the package.

In addition to the project director, there is a faculty committee that oversees the Exxon grant at Hamline. The committee includes both computer users and nonusers. One of the committee's primary duties is selecting the recipients of summer stipends. The committee sought projects outside the science and mathematical areas where computing was already in use. The rationale behind this approach was to involve those faculty members who did

not currently use computing. At times the committee, and Anderson in particular, acted as a missionary and actively looked for faculty who might be interested in a stipend. The committee also screened out those proposals that seemed infeasible or were unlikely to be useful in the classroom.

The grant program at Hamline has been fairly successful to date. As Anderson stated, however, this may be due to limited initial expectations. Some stipend recipients, for example, had not previously used computers. Thus Anderson is satisfied if they are making progress relative to their starting point. The summer projects started several faculty members thinking about computing and its interaction with their discipline. Some faculty have brought discussions of computing into their classes even if there is not any hands-on use. This is consistent with Anderson's approach to computer literacy. He does not think that integral computer use is appropriate in all disciplines and is quite satisfied to encourage incidental use.

While improvements are possible in future workshops, there is general agreement at Hamline that the first workshop was successful. Between 40 and 45 faculty members were present for at least part of the October workshop which was scheduled for a one-day mid-term break.

One of the most successful summer projects and workshop presentations was that of a part-time English professor who explored word processing capabilities on the VAX. He wrote a handbook that distilled in brief form how to use a system editor (EDT) and formating program (Runoff). His work has made word processing more readily available to both students and faculty. Word processing is catching on as a popular computer application at Hamline. The word processing handbook is an example of what Anderson views as a possible series of computing modules that could be used in other courses where appropriate. He hopes to encourage another faculty member to develop a summer project which would produce a similar handbook on spreadsheet use.

Kenneth Janzen, Dean of Liberal Arts when the grant proposal was written, felt Hamline faculty would begin to learn about and use computing when faced by students who were computer literate. The summer stipends from the Exxon grant certainly provided another motivating force for faculty involvement in computer literacy. It is clear that some of the recipients pursued computing because of the stipend. But Hamline faculty also feel the pressure that Janzen spoke of. It comes from students, but more importantly it comes from the college and faculty colleagues. Computer literacy is part of Hamline's environment. Particularly younger faculty members feel that they should be involved in the college's computer literacy efforts. It is not clear that such involvement will be directly rewarded at points such as evaluation for tenure, but the absence of involvement might be conspicuous.

Hamline's size is another positive factor in the grant program. Faculty are aware of what others are doing and communicate among each other fairly easily.

One of the biggest problems to date in meeting the goal of computer literacy for students and faculty appears to be Hamline's computer system. The college purchased a new system to support the computer literacy requirement. (In fact the cost of purchasing the VAX was one of the major considerations at the faculty meeting when the college approved its computer literacy requirement.) Hamline does not, however, provide full-time personnel to manage the computer center. A faculty member is director of academic computing and there is one part-time employee to operate the VAX. This means that some users perceive a slow response to requests such as obtaining course accounts. Users also feel that the system has not been stable or reliable. Last summer the unlikely occurrence of a lightning strike did considerable damage to the system and it took a great deal of time to actually

determine the extent of damage. In addition the operating characteristics of the system were changed at the start of the Fall semester. Faculty who had prepared for class use based on the old procedures found their materials out of date. Some were not able to incorporate changes and so did not use the computer as they had originally planned.

Another factor which has prevented faster progress is inertia. It is not an easy matter to involve and interest a large number of faculty members in a short period of time. As one faculty member stated, the college is like a boa constrictor that ate a whole pig because it looked so attractive, and now is finding digestion a slow and difficult process.

Hamline has made progress relative to its position several years ago. The institution undertook an ambitious project when it passed the computer literacy requirement. Once the requirement was in place it needed a means of ensuring that more of its faculty members became computer literate, could work with computer literate students, and bring computing to their disciplines. Faculty at Hamline are beginning to use computing or incorporate some aspect of computing into their classes. This does not have to be a hands-on use, it can be a discussion of computer use in a medical ethics course, for example. Such incidental use, which really may not be so incidental, helps students learn about the impact of technology and how computing affects their lives. Several faculty members reported that their introduction to computing has improved their ability to teach and help students understand how to approach problems and analysis.

Hamline has really just begun the process of helping its faculty become computer literate. The Exxon grant will enable sixteen faculty members to explore the computer in a way which otherwise they would not likely do. Through the workshops they can spread their knowledge and understanding to others on the campus.

MARYMOUNT COLLEGE

Marymount College requested funds from the Exxon Education Foundation for a number of different projects which form a general effort to further the introduction of computing at the college. Specifically, the proposal asked for funds to: (1) develop a minor in computer science, (2) retrain two faculty members to teach computer science, (3) add two new education courses in the area of computing in the schools, and (4) revise existing courses to include computing (primarily through faculty development activities during summer workshops). All of these have happened and the grant has concluded.

Marymount now offers a minor in Computer Science through the mathematics department. In addition, the college recently received state approval for a major in Computer Science. The college views this as a logical extension of the progress to date with computing. The program follows the Association of Computing Machinery's guidelines for computing majors at small colleges. A major of this type is not unusual for the college since it already offers career-oriented majors in areas such as fashion design and business administration that might not be found at some liberal arts colleges. The college estimates that the number of new students in computer science will provide more than enough tuition income to support the major. In fact the description of the new program focused on student demand and "national need" for computer science majors.

Marymount's second goal, retraining faculty, is an integral part of its efforts in computer science. Marymount knows that it will be difficult to attract new faculty members to teach in computer science. Thus two Marymount faculty members (both from the mathematics department) are

pursuing masters degrees in computer science. The college funds them through grants. The college expects to hire two faculty members in the next two years to teach in computer science. It is looking for candidates with masters degrees. The retraining program has been an effective means for the college to meet some of the demand for computer science courses with its existing faculty.

The college also has two new course offerings in the Education Department. Taken in conjunction with two computer science courses they constitute a concentration in computing for education majors. One course evaluates educational software and serves as an introductory course. The second teaches students to write their own educational software. A faculty member developed both courses as part of the summer workshop series.

The summer workshops were the final part of the Exxon grant process. The workshops followed a model developed under Marymount's National Science Foundation CAUSE grant. These workshops were the first instance of Marymount paying faculty members for summer faculty development activities. According to participants and an outside evaluation consultant, the Exxon workshops were successful. Faculty members from many departments participated in the workshops. They were paid to attend a workshop for up to four weeks. Many participants feel that being paid for their time and effort was crucial because otherwise they would have been forced to find other summer employment. A great proportion of time in the workshops was spent in individual activities designed to help the faculty member learn about a new software package or language that he or she could apply in the classroom. In addition to the individual work, however, there were some group discussions and demonstrations. The second summer workshop benefited from the leadership provided by several faculty members and the new manager of the

computer center. In the first summer it became evident that leadership was necessary, especially for those faculty members with little previous experience with computing.

The results of the workshops are now evident in Marymount's course offerings. The director of the computer center estimates that about 85 percent of the college's students use computing at some point during their studies. The college now has a computer literacy requirement for all students so that figure should increase to 100 percent shortly. Computing has become part of the curriculum in a number of ways. It appears, however, that there are not any major course revisions or innovations that use computing. The largest use of computing is in the programming courses. After this it is used for data analysis, computer-aided instruction (CAI), drill and practice, or class simulations. Some faculty members have found it difficult to revise existing courses to include computing because they cannot add computing without removing something else. Thus in some courses computing is an optional part of the course work or counts for only a very small percent of the course grade.

There are a few surprises in computer use at Marymount, however. The business department has done very little with computing although it seems a natural area for such activities. This lack of use demonstrates the faculty dependent nature of computing at many colleges -- computing does not advance without faculty interest and support. There are other areas which some critics would feel are not using computing to the fullest possible extent. One example is the use of CAI. Such exercises can be useful tools, especially when CAI reflects the curriculum's focus on competency or mastery learning using behavioral models. Uses such as the CAI exercises and computer-based testing have met with mixed success from the students' perspective. Some students like these activities while others do not.

The workshops also became a focal point for faculty-to-faculty contact. This was enhanced in the last workshop when faculty from the previous summer were invited back to discuss how they had used computing in the past year. There is some sentiment that more could be done along these lines. Other faculty members do not feel that it is worth their time and effort to try to interest colleagues in computing. They see apathy among some colleagues and do not want to spend their time trying to overcome this. The basic approach seems to be to let interest develop on its own among the faculty, but then try to support the interest through user-oriented personnel, a willingness to help less knowledgeable colleagues, and programs like the summer workshops.

Marymount continues to use external funding to support start-up activities in the area of computing. It does not commit internal funds to new projects. There is some feeling that the Exxon grant served as seed money by attracting funds from other sources. The Exxon program demonstrated the school's commitment and previous success with computing. Marymount still seeks external funds for computing, but funds on-going activities internally.

While Marymount has enjoyed success in attracting external funds, it is not as easy to find the time for faculty members to work with computing. Summer workshops have been effective in providing time for faculty members to learn what computer resources are available on the campus and how to fit them into currently offered courses. Because of heavy teaching loads and community service commitments, however, faculty members have only limited time to learn about computing during the regular school year. The summer seems an ideal time for many faculty to learn more about computing and work on revising their courses, provided that they are paid for their efforts.

People are another limited resource at Marymount. The success of computing efforts at Marymount has depended on the hard work and dedication of a small group of faculty members with interests in expanding computer use at the college. The CAUSE grant, which funded Marymounts' first computer efforts, arose from a faculty initiative. Without this group or a similar one it is doubtful that Marymount would be as active in computing as it is today. Those interested in computing are still a great asset to the college. They have maintained an attitude of helping others even at the expense of curtailing their own work. Finally, the lack of people was evident in the training during the workshops. Without one or more leaders, the workshops could have suffered from a lack of direction. Luckily interested faculty members stepped in to fill the gap and thus provided leadership. Now that the college has a manager of its computer center, this problem should be alleviated to a large degree.

The final resource of importance at Marymount is knowledge. This is closely linked to people but stands apart. Only a small group at Marymount has much knowledge of computing, although this is changing rapidly. It is also apparent that Marymount administrators, like their colleagues at many colleges, lack sophisticated knowledge of computing. Thus decisions depend on one group of interested faculty members. Lack of knowledge also affects the acquisition of new software for course use. Faculty members are never certain of the software that they order from CONDUIT and other sources. This means that time must be spent evaluating the software and adapting it to the college's computer. Finally, faculty members who are not familiar with the computer may feel some embarassment in learning to use the machine alongside students. Without basic knowledge, they lack the desire to learn more or are fearful of approaching the machine.

Computing at Marymount will likely expand in the years to come, particularly with approval of the computer science major. Most initiatives will probably come from the faculty. The administration supports computing but it is not clear that the college fully understands the potential of computing as it could be used throughout the curriculum. But this is not surprising in light of the fact that the college has not had a deep involvement with computing for many years. Increased sophistication is likely to follow from increased experience.

The college is planning for expanded computer use. There are plans to upgrade the present facilities, especially because of the computer science major. Once again, however, available resources may determine the shape of computing at Marymount. A good example is evident in the use of microcomputers. The college currently owns two Apple IIs. Demand on these machines is growing. The computer governance committee has discussed the need for more micros. But a decision seems to hinge on the possibility of a grant or gift of machines from IBM. While this may not be an ideal path, it may be the most realistic one for a college with limited resources for computing.

Marymount has made considerable progress since the CAUSE grant funded the first computing efforts at the college about five years ago. Progress has been dependent, however, on the efforts of a small group of faculty members with a keen interest in expanding computing at the college. Their work is spreading to others on the campus and it appears likely to continue in this fashion. The other motivating force at the college has been student interest in computing. Some faculty report that the mere mention of job payoffs for learning anything about computing immediately captures student interest. The growing number of students using the facilities also

demonstrates this interest. The college is capitalizing on growing student demand with the minor in computer science and the new proposed major.

While Marymount is not a leader in computing in higher education, the path the institution has followed is not unusual. Dependence on already overworked faculty, slowly growing interest among the faculty who have not previously used computing, and a push from student interest characterize these campuses.

SMITH COLLEGE

Smith's grant is more limited than some of the others the Exxon Education Foundation has funded. Its major focus is developing software for introductory geology courses under the direction of one faculty member, Professor Robert Burger. A secondary activity is compiling of a catalog of geology courseware available from other sources. From the progress reports submitted to Exxon, written documentation supplied by Professor Burger, and a telephone conversation with him, it appears that the grant has been successful -- the original goals of the proposal have been met or will be by the end of the grant period next summer. Burger, in fact, feels that his experience with the project is producing unanticipated and far-ranging outcomes.

Burger originally intended the "Catalog of Computer Programs Used in Undergraduate Geological Education" to be a small part of his entire project. He shipped about 300 copies of the first edition. He sent out another 200 copies of the second edition upon request. The second edition is also appearing in the Journal of Geological Education. This is generating a greater level of interest than Burger anticipated and demanding more of his time and resources than written into his grant proposal.

Burger now uses the software he has developed in his introductory geology courses. As a result he spends more time on the topics for which he has computer modules. He spends one day introducing a topic in a general lecture format and a second day exploring the topic through the software simulation. He feels this allows the students to get a better grasp of the subject and the processes involved in the topic--for example the growth of sand spits in a coastal region or the condition of an aquifer. Color graphic animation lends itself to geological subject matter such as these topics and

others. Burger feels the software encourages discussion and prompts the students to ask "What if ..." questions. He feels that color graphics are particularly valuable in geology. Thus the software is useful in his classes, but he has not altered the courses in any fundamental way. Burger plans to release his software in the next few months. Although he has not yet announced this, he has already received more than fifteen requests for copies.

Burger has no formal evaluation of his software and admits to a somewhat biased perspective, but he is adamant in his conviction that the software is successful in the classroom. There is some basis for his conviction, however. Burger evaluated similar but less sophisticated software he developed five years ago through questionnaires, test results, and comparisons of the same course taught with and without computer aids. The results showed that the computer modules increased interest in the subject and retention of the material. Thus Burger feels confident in his appraisal of his new software.

Although it is designed to be "user friendly" and trap common errors, the software has not yet been used in a tutorial format. The basic reason is the lack of a sufficient number of microcomputers. Burger is cautiously optimistic that more micros will be forthcoming, perhaps as part of a capital campaign Smith will announce soon. It will be three to four years, however, before more micros could become a reality under such a scheme.

Burger states that the progress to date would not have been possible without the external funding. He points to the salary for students during the summer, the purchase of microcomputers and software, money for travel to conferences, and summer salary for himself. Each of these contributed to his ability to complete the project in a timely manner. Without the grant he

probably would have pursued the area but would not have been able to complete as much work as he has. It is also interesting to note that his work is now building in ways that he did not foresee at the outset of the grant. In the spring of 1984 he will make several presentations about his work on applying microcomputers in the classroom. He is on the Board of a national association and is responsible for a special project on computing and geology. Burger is surprised that so little work has been done in this area and gratified at the response to his contributions.

In discussing his work and the importance of external funding, Burger notes the value of his own summer stipend. It appears to legitimize the work and provide motivation for concentrated effort. While he may have worked on these ideas without summer pay, he feels it is likely that he would have focused his efforts on more traditional and standard geological research.

Burger plans on writing another proposal this spring to take up where the current grant activities leave off. He wants to extend his work into software for "laboratory enhancements." He has a long list of topics to work on, all of which benefit from color graphics and manipulation of geological data (some of which are available through Landsat photos and the like). He foresees a prototype computer lab to demonstrate to the college the usefulness and need for such facilities. He hopes that a full scale lab might be possible with funds from the capital campaign. He would also like to begin to explore other technologies such as video disk.

Burger does not feel that the kind of work he is doing would be rewarded in the promotion and tenure process. (He is tenured and has served on the promotion and tenure committee for three years.) Although teaching is important at Smith, his impression is that traditional research and publications are much more important. If he were not tenured, he would be

spending less time developing instructional software. He feels the software is decent and a worthwhile contribution, but he senses that some others think he should pursue research rather than teaching support.

Smith has two Digital VAX computers, the second a recent addition to support a new computer science program. The college is just beginning to make acquire microcomputers. Burger serves on a committee to establish better graphics capabilities at the college. While ahead of others at Smith in the use of color graphics, Burger's use of computers seems appropriate for Smith--at least as Burger reports what other are doing. The two primary uses of computing are programming in the computer science courses and word processing. There is also the typical use of statistical packages in the social sciences and so forth. Faculty members in other disciplines are not interested in Burger's work apparently because they do not think that it applies directly to their activities. He has demonstrated his software to faculty members but he has not tried to actively involve others due to time constraints. This spring he will teach a two-day workshop on color graphics techniques available on microcomputers.

Thus Burger has accomplished what he set out to do. His catalog of available computer software for use in geology classes has been well received. He is using his software in introductory courses and has plans for more advanced software that he would like to use in laboratory settings. Others at the college are becoming aware of his work and the capabilities of microcomputers for color graphics. And he has become involved in national associations and is thus extending his experience to many campuses.

SWARTHMORE COLLEGE

Exxon's grant to Swarthmore College is quite specific in its intent and outcome. Exxon funded Professor Eugene Klotz, Department of Mathematics, to develop color graphics software to support instruction in calculus courses at Swarthmore. The project is funded for a year and a half, instead of the requested three years, and Klotz's progress at the end of the first grant period will in part determine further funding. It is important to note that Klotz also received considerable support from the college, specifically about $30,000 for a computer suitable for sophisticated color graphics use. Klotz received these funds through a college committee and fund for upgrading scientific equipment. He states that he "cashed in all of the Math Department's chips at one time" because they had never asked for anything more than chalk.

Acquiring the color graphics equipment took longer than Klotz anticipated. The selection process was lengthy and then his request needed the college's approval. Klotz feels that part of the delay was caused by the normal academic bureaucracy of committee approval. He purchased state-of-the-art equipment from small vendors to get the most for his money. Because the computer did not arrive until August, Klotz's first summer with the grant was not productive in the ways he originally expected. He spent more time on theoretical issues and less on production of graphics modules. During the summer he spent time "getting to know" the equipment. He, and his student programmers, learned how to control the colors, graphing capabilities, and other features of the computer. Klotz feels, most likely correctly, that time spent on these tasks will make subsequent work much more productive. But as a result he has little to show at this point that directly relates to the calculus software he will produce.

Klotz still feels that there are many possible topics that could benefit from computer graphics and he has fairly detailed outline of those he wishes to pursue first. He also recently surveyed his calculus class to learn what material they perceive as most difficult. He eventually wants to use the units as a learning enhancement. Klotz feels that use of the computerized units will increase student learning and comprehension. He does not feel that the computer work will fundamentally alter the way in which he teaches calculus. Eventually, when powerful color graphics are available in affordable microcomputers, he hopes that tutorial versions of his software will be available to students directly. Others on the campus think the cost of Klotz's equipment may be a stumbling block to wide-spread use. At $30,000 per micro the college will not be able to afford many such configurations. Klotz notes, however, that he intends to design the software to run on graphics equipment that by the end of 1984 should cost less than $3,000 per micro. The higher quality machine is beneficial in developing the software.

It is evident that Klotz enjoys his work tremendously. He is building on an earlier NSF-NIE project to computerize, with color graphics on an Atari 800, an entire trigonometry curriculum. The Exxon grant provides summer salary for Klotz and has permitted him to buy back one course this year. It also funds student programmers. Without the grant Klotz feels that he probably would be working on the project, but at a slower pace. He views himself as a software developer and the whole project as a long-term venture.

Klotz feels that the college supports computing on the campus and his efforts in particular. The $30,000 spent on color graphics equipment is evidence of this. He stated, however, that in the tenure review process more would be needed than work in computing. (Klotz is tenured.) As he stated, what is really important is evidence that "moss is not growing over

one at too early an age". Another faculty member commented that innovative teaching is important in tenure review, but it is not the only criterion.

It really is too early to make any definitive statement about Klotz's work on the Exxon project. It is clear that he loves his work, is learning how to get beautiful color graphics out of his equipment, and from past projects knows how to write classroom software. He feels that he will have something worthwhile to show for his work at the end of the grant period. This seems like a very reasonable belief on his part. The expected reduction in the cost of microcomputers capable of sophisticated graphics applications will be a major factor in making Klotz's software more widely applicable.

It is useful to put Klotz's work at Swarthmore into perspective by examining computing in general at the college. Swarthmore uses a centralized system with separate academic and administrative computers (although a few tasks such as statistical analyses share the academic machine and computer center personnel support both user groups). The college purchased a Prime 750 a few years ago and thought that it would provide sufficient capacity for several years. Use grew more rapidly than expected, however. Later this year academic service will be upgraded with a Prime 9950 computer. There is approximately one terminal for every 10 to 12 students (the exact figure depends on who cites the statistic). The terminals are placed in clusters around the campus. Currently about 80 percent of the student body has at least one account on the academic computer.

From the outset the college planned on unrestricted use of computing. This in part caused the early load on the computer as many members of the college community discoverd text processing. (It is important to note that several people I talked with noted a distinction between "text processing" and "word processing.") The college views the computer as a tool just like the

pencil. Writing is taught across departments and many classes use the computer for this task. The chair of the Computing Committee feels that this has improved the quality of student-faculty interaction and the quality of the students' writing. In fact, he thinks that the computer has fundamentally changed the nature and method of the writing courses, or at least the one he teaches in the economics department.

If there is an emphasis on text processing at Swarthmore, some critics feel that computing has not been fully used for other tasks and that the text processing applications have slowed other uses. There are also some complaints among science students who want more computer resources. They feel that the text processing applications use too much computing. The institutional response is that the computer is a tool for all users not just programmers and number crunchers.

Many members of the college community, including students, administrators, faculty, and staff, are introduced to the computer through the introductory course, "Computing from the User's End." The class meets in a weekly lecture format with additional small workshops that stress specific applications for users with interests in different academic subjects. Total course enrollment was about 300 in the first year it was offered and 400 in the second year (this year). According to the faculty member who teaches the lecture session and developed the course, the idea is to "force in a gentle way" most of the college to learn about computing. The course focuses on practical applications not programming. Next year a second semester follow-up course is planned. It will explore topics in greater depth but it too will not be a programming course. The college currently supports "computer science" courses through its engineering department. In the near future it expects to teach computer science through the mathematics depart-

ment as well. A "concentration" in computer science will provide the administrative structure to ease the problems of having faculty members in two departments teach computer science.

Many faculty members have begun to use computing after participation in the introductory course or after special summer seminars which were only open to faculty and administrators. The initiative has been largely faculty-oriented; the administration is supportive as evidenced by sustained funding for equipment expansion, but it has not been the driving force behind computing at Swarthmore. Perceptions of interaction among faculty members depend on who is asked. Those with high involvement in teaching the introductory course feel that there is a great deal of interaction, most likely because they continue as information givers after the courses. Other faculty members do not see this kind of interaction and feel that it really does not exist to a great extent. There are a few missionaries on the campus and they play an important role in the "contagion effect" as one faculty member described.

In general it appears that Swarthmore is a campus of individuals. There is interaction among them but each pursues his or her own interests. Where their paths cross information is shared or missionary activities occur. But the college does not have a wide-spread effort to integrate computing into the curriculum. Klotz's work is one example of faculty directed and initiated computing at Swarthmore.

WELLS COLLEGE

When Wells College received a grant from the Exxon Education Foundation, the college's computer resources and program were limited. Students and faculty used four Heath Microcomputers that several faculty members had built from kits. The grant proposal requested funds to help the college meet several objectives. First was to develop faculty expertise for computing in academic areas. Second was to develop the capability for all Wells students to use computing in their courses. Third was to demonstrate to each student that she could be an intelligent user of computer resources. Fourth was to set up a system for continued growth and support for computing at Wells. Fifth was to accomplish these goals in a manner which could serve as a model for the use of microcomputers at other small colleges. Exxon provided Wells with approximately $50,000 for the 1981-82 academic year and another $25,000 during the 1983-84 academic year. These are large grants for instructional purposes by Wells' standards.

The rationale behind the Wells approach is the "trickle down" theory. The grant writers assumed that faculty had to be able to use and feel comfortable with computing before they could apply computer resources in their classes. Thus the grant proposal focused on faculty first and students secondarily. The result of the Wells computer literacy program has been a rapid and extensive change in the availability and use of computing at the college. Many on the campus are both pleased and surprised by the progress to date. A majority of faculty members and middle to senior level administrators have been involved in some aspect of the computer literacy program at Wells. The college achieved these results through several tactics described in greater detail below.

One of the first activities supported by the Exxon grant was release time for the project director. Arnold Shilepsky, the first project director and Associate Professor of Mathematics, used the period early in the grant to think about what Wells should be doing with computing and to plan grant activities. He conferred with other faculty members and discussed how the college should proceed. Carol Shilepsky, the second project director and Associate Professor of Mathematics, also received a reduction in course load. She used this time for a number of purposes including planning and implementing a popular weekly series of lectures and presentations related to academic computing. Topics included use of standard software packages available to the Wells community as well as special topics such as graphics and robotics.

The second major element of the grant was the purchase of additional microcomputers. Initially this consisted of four more Heaths and a high speed printer. All the microcomputers except one were located in a computer lab. One of the Heaths and a letter quality printer were placed in a separate room and reserved for faculty use. Wells recently received additional grants from Eastman Kodak and Xerox which provided six IBM PCs, 21 Xerox microcomputers, and additional printers. A grant from the Pew foundation includes funds for remodeling existing facilities to relieve somewhat crowded conditions in the computer lab. Several microcomputers were recently placed in other classroom buildings as well. The 27 new microcomputers should improve the availability of computer resources for faculty and students.

Another major activity was designing and offering a basic course on computer literacy to faculty, administrators, and staff at the college. The course was offered five times; once in January 1982, three times during the summer of 1982, and once in June 1983. Each course lasted two weeks. It

included a general discussion of system use, BASIC programming, word processing, academic applications, data base management, and electronic spreadsheets. Morning lectures were followed by afternoon "hands on" sessions in the microcomputer lab. These classes served as the primary means of introducing faculty and administrators to the computing resources available at Wells. The grant directors encouraged each faculty member to concentrate on those computer activities that made sense in light of their courses, needs, and personal interests. Faculty and administrators did not receive a stipend for their participation and this did not reduce interest or participation in the class.

Over the past summer the grant also funded eight faculty members who wanted to pursue individual projects. Each one received a stipend of $500. The project director awarded grants to faculty members who were already active with computing and had particular projects they wanted to pursue. These included revising and expanding software currently used and exploring new areas such as teaching linguistics with a HERO robot.

Finally, Wells has used Exxon funds to support student computer lab monitors. These are knowledgeable students who are available to answer questions for students and faculty members.

Thus the Exxon grant provided important resources for Wells College. The dollars bought valuable time in addition to computer hardware and software. It enabled the project grant directors to consider how the college could use computer resources and what steps were necessary to move the college to a point where computers could and would be used effectively. It supported faculty members for summer activities that they probably would not have otherwise pursued. Finally, it helped Wells attract additional external funds with which to further expand and support computing at the college.

There are a number of factors that have influenced the success of the Exxon project at Wells College. Primary among them is the small size of the college (approximately 500 students and 63 faculty members). There is a sense that the entire campus is involved with computer literacy. Carol Shilepsky now estimates that the project has reached about 80 percent of the faculty. The small size also enhances communication among faculty members. Those who are interested and actively involved with computing have a good sense of what others on the campus are doing with the resource. Thus if one faculty member has a question about a particular application or wants to explore a new application he or she knows who to ask on the campus. This informal network seems to have taken the place of the formalized users group that the original grant proposal discussed.

The computer literacy classes also produced a unified feeling among participants because so many shared a common experience. The courses developed an espirit de corps which might be more unusual at a larger college or university.

Teaching is an important activity at Wells College. While research and publications have received increased attention recently, faculty members feel that they are evaluated primarily on their classroom performance. For this reason many feel that it is valuable to spend time and energy on developing and integrating computer resources for their classes. In addition there is some feeling that at a small college, computer use by those outside the sciences demonstrates valuable flexibility and resourcefulness.

While there is great enthusiasm for computing at Wells, the faculty do not clearly feel the administration's commitment to computing. It is generally acknowledged that the previous Dean did not support widespread computing. External funds have supported the major computing initiatives at Wells, although the college has committed some of its resources as well.

The effects of the computer literacy project are visible at Wells. The students are clearly interested in computing skills. Large enrollments are typical of the computing classes. The college recently approved a new major in Computing and Quantitative Studies. A number of traditional courses also make direct use of computing. French grammer CAI programs, written by a member of the French Department, are available to students who feel the need for additional practice and review. Several statistics courses use software packages. Simulations are available in disciplines such as economics and biology. A philosophy course uses computerized logic exercises and tests. Other courses are being designed around special packages such as Dow/Jones Retrieval. A few faculty members strongly urge if not require students to use word processing software to write and rewrite course papers. There also are more indirect effects such as students using word processing when it is not required and faculty using it for course preparation.

While Wells offers a traditional liberal arts curriculum, it does so with the realization that most graduates pursue careers. In this light computing provides specific skills. Students see evidence of this in their ability to obtain internships and jobs. This is another indirect benefit of the computer literacy program.

An additional consequence of the Exxon program is the spread of computing into the Wells administrative structure. The college had not computerized administrative functions prior to receipt of the Exxon grant. Administrators participated in the computer literacy courses and thus expanded their awareness of computing. This has had direct benefits in offices such as admissions which purchased microcomputers. Because students who work in adminstrative offices are knowledgeable of computing, they may suggest how to computerize office functions. One student, for example, designed a computerized billing system. Another performed analyses for the admissions office.

Thus the Exxon grant to Wells has been instrumental in a rapid and extensive change at the institution. In approximatly three years Wells has gone from a position where most faculty members were not familiar with computing to one in which 80 percent of the faculty has participated in a computer literacy course. Faculty members in diverse disciplines routinely use computers and feel comfortable if not expert. The grant provided the necessary time and money to enable the college to make this shift. It is apparent that the faculty currently has the momentum and interest to continue the expansion of computing at Wells.